Base Development in Modern Contingency Operations: Can Active Army Engineers Meet the Task?

A Monograph
by

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Following a review ans analysis of Army and engineer doctrine, the paper then examines the historical example of base development offered by Operation OVERLORD in June, 1944. The engineering operations carried out in the invasion of Normandy are used as a model for all modern engineer operations in support of large operations in an austere theater. The paper then discusses the engineer requirements for base development in a hypothetical corps-level contingency operation in Southwest Asia. The basis for the case study is the USCENTCOM exercise conducted annually by the School of Advanced Military Studies. (continued on reverse)

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Finally, conclusions are made that address the capability of the Active Army engineer force to support modern contingency operations in an austere theater. Recommendations for operational level engineer considerations include force structure, development of common joint engineer doctrine, and the need for joint operational level training for senior engineer officers of all services.

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This monograph discusses the importance of base development to operational sustainment and the role that Army engineers will play in modern corps-level contingency operations. Base development in an austere theater will be a complex task that will involve close coordination and planning among not only all services of a joint task force, but also among the numerous branches of the Army. This monograph examines base development requirements with regard to current Army doctrine and engineer force structure.

Following a review and analysis of Army and engineer doctrine, the paper then examines the historical example of base development offered by Operation OVERLORD in June, 1944. The engineering operations carried out in the invasion of Normandy are used a model for all modern engineer operations in support of large operations in an austere theater. The paper then discusses the engineer requirements for base development in a hypothetical corps-level contingency operation in Southwest Asia. The basis for the case study is the USCENTCOM exercise conducted annually by the School of Advanced Military Studies (SAMS). The discussion goes into much more detail than the SAMS exercise schedule allows and, therefore, offers a much more detailed analysis of the operational sustainment issues that are affected by military engineering.

Finally, conclusions are made that address the capability of the Active Army engineer force to support modern contingency operations in an austere theater. Recommendations for operational level engineer considerations include force structure, development of common joint engineering doctrine, and the need for joint operational level training for senior engineer officers of all services.

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> "The first point in a plan of operations is to be assured of a good base; this name is applied to the extent of the frontiers of a State from whence an army will draw its resources and reinforcements; that from whence it will have to depart for an offensive expedition, and where it will find refuge in time of need..."[1]
>
> -Jomini

Section One. Introduction.

The decreased likelihood of a major land war in Europe is giving way to an increased threat of low to mid-intensity warfare throughout the world. This has placed a greater emphasis on the Army's strategic ability to respond to threats to the security of our own nation, our allies, and other governments. Therefore, the Army must be prepared to conduct combat operations as an expeditionary force anywhere in the world.[2]

Ideally, Army forces may be employed in a theater where there exists an adequate support structure, such as Panama during Operation JUST CAUSE. However, the Army of the future must be capable of fighting in a theater with austere support facilities. The existence of little or no in-theater support bases may require that a large logistic organization accompany the Army force.[3] This would involve the systematic and well-planned development of an operational sustainment base.

From an operational standpoint the first logistical element to consider is the base of operations.[4] It is even more crucial if a large force is to be introduced into an austere theater of operations. The scheme for base development is therefore a key part of the operational level plan.

The base development plan is the product of concurrent planning by the commander of a joint command and the commanders of the component services involved in the operation.[5] It can neither be effectively

accomplished through independent planning by each involved service, nor can it be planned within the Army force component by a single branch.

Development of an operational sustainment base in an austere theater will be a major undertaking. Although the force executing a contingency plan in such a theater will most likely be joint, each service should be expected to provide the required construction and engineering support for their respective forces.[6]

This paper, therefore, examines the role of the Army Corps of Engineers in base development in an austere theater of operations. It will provide an answer to the problem confronting engineer force planners today: Can active component engineers meet their responsibilities in support of operational sustainment in the expected austere theater of operations in the future?

The analysis begins with a proposed definition of military engineering at the operational level. This discussion will center on types of engineer units and missions. This will be followed by an examination of current doctrine for the employment of engineers in a theater of operations with respect to their necessary interface with both maneuver and logistics elements of the force. Using this analysis, I will propose a set of criteria that may be used to evaluate engineer capability in future operations.

An historical case study will then be analyzed. Although the French infrastructure was well developed prior to World War II, extensive damage by allied bombing had stripped away all but the skeleton of the French communications and support systems. The development of the Normandy lodgement area in support of Operation OVERLORD therefore provides an excellent example of engineer support in an austere theater.

The analysis will provide a synopsis of the engineer operations required to support the base development for a mechanized force.

A second case study will present a modern operational scenario. The study will be based on a fictional deployment of a joint task force to the Arabian peninsula. It will serve as a stage on which I will portray the logistical requirements that drive engineer planning and execution in support of base development.

Section 2. OPERATIONAL MILITARY ENGINEERING.

Before any further discussion, it is necessary that I assert the major differences between operational and tactical level engineer tasks. Tactical engineer units provide responsive mobility, countermobility, and survivability support to the combat force. Tactical engineer units do not fight alone but are part of the combined arms team and all of their activities make [the team] more effective.[7] The tactical support provided by combat engineer brigades and divisional battalions are generally limited to a corps main battle area.

Military engineering at the operational level requires a much broader and more technical perspective. Engineer planning and coordination in close cooperation with the other technical branches (*eg* the Transportation, Quartermaster, or Medical Corps) is the hallmark of operational level engineering. The primary concern of military engineers at the operational level is the sustainment base of the theater, including the requirements of other services and allied military forces. Their primary role is to ensure that engineer support in the communications zone (COMMZ) meets the needs of the forces in the combat zone.[8]

Field Manual 100-5, *Operations*, defines operational sustainment as those logistical and support activities required to sustain campaigns and major operations within a theater. It extends from the theater sustainment base which links strategic-to-theater support functions to the foward CSS facilities and units organic to major tactical formations.[9] FM 100-5 also details five vital components of operational sustainment: lines of support, staging, altering lines of communication, sustainment priorities, and force expansion. Each of the components are heavily dependent on engineer effort.

In future large-scale contingency operations, units and equipment must travel from their bases, through an operational support area, and into the combat zone. <u>Lines of Support</u>, either interior or exterior, require major engineer concentration. Entry points into a theater of operations will be either seaports or airfields. Engineers will be needed to open ports and airfields in the COMMZ and keep them in operation. Maintaining the physical capability of land lines of communication is strictly an engineer function.

As Jomini stated, a good base of operations is essential to success. Properly planned and executed <u>staging</u> may be critical to success in an austere theater. Construction of bases along lines of support and lines of communications will require a tailored engineer force whose introduction into the theater is carefully sequenced to match the expanding requirements of the total force.

Once engaged, the combat forces in the theater must retain their mobility and flexibility. Engineer support for <u>altering lines of communication</u> may pose difficulties to the engineer force. A line of communication (LOC) is a tangible element along a more general line of

support. The LOC is fragile and capable of failure due to overuse. Preparing for this component of operational sustainment will require that engineer forces perform their LOC maintenance tasks throughout the width and depth of the area of operations. This requires that appropriate engineer units be in the theater at the right time and that they act in accordance with a well defined plan based on the fourth sustainment component, sustainment priorities.

Prior to the introduction of the engineer force into the theater, the sequence of construction tasks will have been planned to meet the sustainment priorities set by the theater commander. The establishment of the engineers' priorities of work will affect their sequence of arrival into the theater and, subsequently, their capabilities during the early stages of base development. The ill-timed arrival of an engineer unit with unique capabilities could jeopardize the build-up of combat forces in theater and perhaps the entire campaign.

Finally, engineers are critical to force expansion in the theater. Larger forces require a greater number of facilities. Engineer planners, in cooperation with those of other branches and services, must anticipate an increase in forces in the theater and build to support them prior to their arrival. Force expansion will place a heavier burden on the engineers for support facilities and LOC maintenance.

Base development in the COMMZ is therefore the primary area of concentration for engineer tasks in support of a theater. Maintenance of the strategic-to-operational points on the lines of support, as well as the lines of communication within the theater, are major tasks. A wide range of work performed by engineer units is also necessary for the operational sustainment base of the theater of operations. The scope of

the responsibilities of the Corps of Engineers may best be understood by examining our general engineer doctrine.

Engineer doctrine in support of the operational level of war should support Army doctrine. However, our general engineer doctrine does not specifically identify operational level engineer tasks. Engineer doctrine on an operational plane must mesh with the components of operational sustainment discussed above if the engineer community is to fully understand its role in modern contingency operations.

Field Manual 5-100, *Engineer Combat Operations*, provides a brief discussion on the five engineer battlefield functions. Three of them, mobility, counter-mobility, and survivability, are clearly identified as supporting the tactical battle. The fourth, sustainment engineering, is predominantly an operational level function. The fifth function, topographic engineering, may be an operational function although most topographic work in support of a future austere theater of operations will have been accomplished prior to the commitment of forces; this is, in a sense, an aspect of strategic level engineering.[10]

Engineering in support of the operational level of war is weakly addressed in a relatively new publication, FM 5-116, *Engineer Operations: Echelons Above Corps*. This manual, published in 1989, prescribes the doctrinal relationship between engineer operations and theater organization. Primarily intended for an engineer audience, the doctrine addresses all major aspects of engineering at the operational level: base development, construction planning and management, rear area and area damage control operations, real property activities and host nation interface, and engineer logistics. The doctrine prescribed is useful in the sense that it provides guidance to engineer planners

which complies with joint logistics policy as specified in JCS Pub 3, *Joint Logistics Policy and Guidance*, (July, 1979).[11]

Field Manual 5-104, *General Engineering*, however, provides the best general guidance to the operational level engineer planner. This manual clearly defines construction standards and the principles of theater of operations construction: speed, economy, flexibility, decentralization of authority, and the establishment of priorities. Each major type of engineering construction and support activity (port construction, airfield construction and rehabilitation, real estate management, *etc.*) is well discussed to include inter-service construction responsibilities and construction policy guidance.[12]

Although the above FM 5- series manuals provide very good doctrinal guidance to engineer planners, one other manual is useful for tying the efforts of engineers to the complete operational sustainment picture. FM 100-16, *Support Operations: Echelons Above Corps*, provides a combined arms approach to the organization and function of engineers in support of a theater of operations. An important and unique aspect of the discussion in this manual of engineer operations is the emphasis placed on the need for engineer intelligence: "Commanders of unified commands are responsible for ensuring that civil engineering intelligence require-ments are defined and resources requested in the *consolidated intelligence program* (emphasis added)."[13]

It seems, therefore, that the Army engineer force is well-armed with an adequate doctrine that supports operational sustainment in a theater of operations: Sustainment engineering tasks are identified, responsibilities for construction in the COMMZ are well-defined, and engineer effort is tied into sustainment doctrine.

But what types of engineer units may be considered as assets at the operational level? Without the benefit of a doctrinal definition, my assertion is that an operational level engineer asset is one that is used primarily for the construction and maintenance of support facilities that support the components of operational sustainment discussed earlier. Examination of FM 5-100, FM 5-104, and FM 5-116 suggests that the following types of engineer units are operational assets.[14]:

Type Unit	Basis of Allocation (SWA)
Engineer Battalion, Corps (wheel)	1.5/LID, ABN, AASLT Div; .5/MX Div
Engineer Battalion, Combat Heavy	1/Div (all types)
Combat Support Equipment Company	.5/Engineer Bn, Corps
Construction Support Company	.5/Engineer Bn, Combat Heavy
Dump Truck Company	1/Construction Support Company
Float Bridge Company	1/HQ, Theater Army
Light Equipment Company	1/Abn, Light Infantry Divs
Panel Bridge Company	4/HQ, Theater Army
Pipeline Construction Company	1/HQ, Theater Army; 2/HHC, ENCOM
Port Construction Company	1/major port
Technical Teams	Variable; usually allocated based on numbers of HQ, TA or HQ, ENCOM

These types of units represent what is found in both the active and reserve components. However, those units that I have suggested as being in support of the operational level are primarily found in the reserve components. The effects of this will be discussed later.

The Army and the Corps of Engineers have a workable doctrine that will support an operational campaign in an austere theater of war. The key to engineer success is their ability to support the deployment, build-up, and continual sustainment of the force. The broadest mission that engineers may have at the operational level is simply to prevent the maintenance of the operational sustainment base from becoming the

center of gravity for friendly forces.

Therefor_, any criteria for engineer success must be with respect to the total force. Criteria for operational engineer support is heavily dependent upon the components of operational sustainment described in FM 100-5. The relation between these two can best be summarized in the table below:

Components of Operational Sustainment

Criteria Concept	Lines of Support	Staging	Lines of Communication	Sustainment Priority	Force Expansion
Support Deployment	X	X	X		
Support Build-up		X	X	X	
Sustain the Total Force			X	X	X

Therefore, the following criteria are suggested for the successful engineer support of the operational sustainment base:

- Engineers must maximize capacities of airfields and ports on the first day of deployment.

- Engineers must meet minimal construction requirements to support a rapid build-up in the combat zone and COMMZ.

- Engineers must meet all planned construction requirements in the theater to sustain the total force.

Are these criteria valid? An examination of the engineer support for Operation OVERLORD and a hypothetical, modern Southwest Asia scenario will provide the answer.

Section 3. Operation OVERLORD: Base Development in Normandy

The official US Army history has described Operation OVERLORD as the supreme effort of the Western Allies in Europe.[15] General Omar Bradley termed the Normandy invasion "an Allied triumph on a magnificent scale."[16] However, the invasion was not conducted as an end in itself but as a means to an end. The purpose of OVERLORD was to push the enemy forces out of a lodgement area that was defined broadly for the logistical purposes of remaining ashore. Once the Allies had consolidated in the lodgement area, assembled supplies and troops and developed airfields, they would continue the assault against the enemy.[17]

With the emphasis placed on securing a lodgement area, base development in Normandy was an important part of the OVERLORD plan. OVERLORD planners were expecting the existing French communications infrastructure to be extensively damaged due both to Allied bombing that preceded the invasion and by deliberate destruction by the Germans. This line of thought was influenced by the widespread rail and road demolition experienced in Italy.[18] Engineer planners assumed that most port area buildings and equipment would be destroyed and ships sunk in the harbors.[19] They therefore assumed that the build-up would have to be done in a devastated area or, in today's parlance, an austere theater.

The base development plans were very detailed. The beaches were to be the initial bases followed by the establishment of bases in the Cherbourg and St. Lo areas. The lodgement area was to be the origin of all railroad, pipeline, and road construction.[20]

The extensive base development requirements generated a continuous

debate over the appropriate ratio of combat, air force, and service troops. The emphasis on the build-up required a larger number of service troops.[21]

Engineer units comprised a large portion of the COMMZ troops. By D+10 (16 June 44) fifty-four of a total of 112 United States COMMZ units that were to have arrived on the continent were engineer organizations. Most of these were port construction units.[22] In the overall plan for Europe, engineers were to comprise twenty percent of the total service forces expected to support the American armies in the field.[23]

Engineering work on the continent was critical to tne success of the tactical plan. A variety of tasks had to be done. Engineer planning and intelligence were crucial first steps for base development. Map production and distribution were required on a grand scale. Port rehabilitation, logistics over the shore, airfield construction and rehabilitation, highway and railway construction, POL distribution networks, facilities construction, utilities, and real estate management were all necessary COMMZ actions for support of the combat force. Each of these will be discussed in more detail.

The Engineer Intelligence Section of the ETO was activated early in the United Kingdom. Prior to the Normandy invasion it had already established liaison with other theater intelligence agencies, collected much intelligence pertinent to the initial landing area, and developed intelligence collection plans for use on the continent.[24] Although engineer intelligence officers used a variety of sources, their primary tool was aerial photography. Determination of requirements for LOC maintenance and construction, for example, was heavily dependent on photo interpretation.[25]

Topographic operations were directly related to engineer intelligence collection and aerial photography. In support of the engineers' map-making tasks, the air corps began aerial photography of over 10,000 square miles of northern France in June, 1943. In planning map production, the engineer intelligence division had to consider what map series were to be completed, which maps would be needed by which forces, which map production equipment could be employed in the field, and how much time was available.[26] By January 1944, Americans and British had produced maps of over 16,000 square miles of the OVERLORD area.[27]

Detailed engineer planning began in June, 1943. Detailed studies and planning for engineer support in the COMMZ were initiated in a program labeled Projects for Continental Operations. The engineer staff planned requirements based on the maximum forces to be employed in active operations, the total number of lines of communications, the total number of ports to be built or rebuilt, and the number of airfields required. The requirements were phased in accordance with the expected ground tactical plan; for example, on D+240 the lines of communication were expected to be over 200 miles long.[28]

Every aspect of engineer operations in support of OVERLORD was focused on base development on the continent. Rehabilitation of damaged facilities and the construction of new ones were the *raison de etre* for every engineer unit serving in the COMMZ. The cumulative results of their efforts were impressive.

The immediate concern to COMMZ engineers was the organization of the landing beaches. The first priorities of the engineers in Normandy was the "...provision of facilities to permit the discharge of cargo thru [*sic*] the use of DUKWS, lighters, and coasters, and rapid clearance of

landing areas..."[29] To accomplish this, over 30,000 engineers were organized into engineer special service brigades.[30] By D+12 the American beaches were clearing 14,500 tons of supplies (about 96 percent of the target), 19,000 men, and 2,800 vehicles daily.[31]

While the organization of the beaches and the artificial harbors was important for the initial supply and build-up of forces, the major logistical support was expected to be progressively assumed by the larger deep-water ports.[32] By D+30 14,500 tons per day were to pass through both the major and minor ports of Normandy. By D+60 it was to be 26,940 tons, and by D+90, 33,950 tons.[33] To accomplish the planned rehabilitation of ten major and minor ports, the following types of engineer units were formed and deployed:[34]

- 7 - Headquarters and Headquarters Companies, Port Construction and Repair Groups
- 6 - General Service Engineer Regiments
- 1 - Special Service Engineer Regiment
- 5 - Port repair ships [manned by Army engineers]
- 4 - Sea-going hopper dredges
- 5 - British grab and/or bucket dredges

Final development of nine of the ten planned ports allowed a cumulative capacity of 36,050 tons per day.[35]

A significant amount of engineer effort was devoted to airfield construction. The recognized need for forward air bases was so great that an aviation engineer regiment was especially created for airfield construction on the continent. By D+40 over 16,000 engineer aviation troops in France had placed eighteen fields in operation; by D+100 this number had risen to 67 fields completed with ten more operational though still under construction. Although the airfields were primarily for combat and reconnaissance aircraft, by D+90 some 30,000 tons of supplies had been flown into the theater and 40,000 casualties evacuated back to

England.[36] The tactical successes in France would not have been possible without the close air support that flew from the forward airfields.

The OVERLORD logistics planners did not expect to use an elaborate railway network in France in the first few months.[37] However, railways would play an important role in resupply once the pursuit across France began. Engineer planners deemed it "...necessary that railroad reconstruction and repair be expedited to the fullest practicable extent... to place the railroad system as designated in the Com Z [*sic*] plan in operation as soon as possible and ahead of the indicated phase schedule."[38] Based on intelligence estimates, engineer forces were allocated for railroad work. One engineer general service regiment, augmented periodically by engineer construction battalions, constructed or rehabilitated over 1900 single track-miles from Normandy to the Seine, including bridges.[39]

The Corps of Engineers began planning the road repair and highway bridging requirements for OVERLORD almost two years before the invasion. No major problems were anticipated due to the traditionally good road system in France and enemy-inflicted damage to highways was not expected to be great.[40] Nevertheless, heavy loads and the use of tracked vehicles would subject many of the roads to traffic for which they were never designed.[41] Therefore, between D-Day and D+90, engineer forces that were to be committed to road repair numbered seven general service regiments augmented by civilian and POW labor.[42]

Manpower was also consumed by the requirements for transporting petroleum. Although the Transportation Corps had the greatest responsibility in transporting POL, it was the Corps of Engineers that

had the most extensive mission. The engineers not only had to construct all bulk POL facilities (storage areas and pipelines) but they had to operate them.[43] By 10 September 1944, over 210 miles of six-inch pipeline with pumping stations and distribution systems had been constructed across France.[44] The engineer force assembled for this task was an engineer general service regiment augmented by an additional construction company and seven engineer petroleum distribution companies.[45]

In addition to the need for lines of communications, facilities were also required. General construction on the continent was to be minimal both in quantity and standards. The engineer COMMZ plan estimated that 67% of the total requirements for facilities such as hospitals, shops, depots, refrigerated warehouses, and POW camps would have to be met by COMMZ engineers. Troop camps were to be built for 30% of the force.[46] Over 62.7 million manhours of labor (including military, civilian, and POW) were used in France alone to provide the minimal requirements.[47]

Two other engineer activities require discussion: utilities and real estate management. Utilties operations in the COMMZ were primarily restricted to the rehabilitation of in-place networks to support COMMZ activities. Although electricity and water production were their primary activities, mine clearance, cemetery construction, quarry operations, and debris removal were also the responsibility of the engineers in the COMMZ. Nearly 18 million manhours were expended on utility operations in France alone.[48] Real estate activity was a combination of property acquisition and management and the coordination for civilian labor. The real estate section of the COMMZ engineer was minimally manned and, by all indications, was not a priority effort.[49]

From the preceding discussion it is evident that the engineer activities in support of base development in the COMMZ were diverse. Every aspect of the engineers' tasks was crucial to the success of not only the OVERLORD plan but the subsequent pursuit across France into Germany. Considering the scale of the entire operation, the engineer planners, in cooperation with the other technical branches, did a remarkable job.

Engineer support of the ETO communications zone was an unqualified success with respect to the criteria suggested earlier. Engineer support of deployment (i.e. the amphibious assault), the build-up, and force sustainment was well planned and executed.

Engineers performed important tasks on the beaches during the landings and subsequent days in support of deployment. Engineer work on the beaches on D-Day and the few days following allowed the planned deployment of units to continue at nearly the planned rate. By D+12, combined daily discharges of supplies at OMAHA and UTAH beaches were just below expectations and over 314,000 American troops were ashore along with 41,000 vehicles.[50]

Engineer support of the build-up began immediately once the proper engineer forces were ashore. The engineers had the first port in France ready for operation on D+11, ahead of schedule. Operational level engineer support of the build-up was not a limiting factor in the tempo of operations. All requirements for construction were met and limited only by the relatively slow progress of the ground battle and the resulting congestion in the developed lodgement area prior to the breakout, Operation COBRA, on 25 July.

Development of the American forces' sustainment base was the

greatest accomplishment in the Normandy campaign. The opening of railroads, POL pipelines, and highways was crucial to maintaining the tempo of operations. Airfield construction and rehabilitation were essential to tactical air support throughout the campaign in Europe. Facilities construction was necessary to health and welfare of the troops in the theater.

Operation OVERLORD gave the Corps of Engineers a model for future joint and combined operations. It proved that joint planning with other branches and services is critical for success in the deployment, build-up and sustainment of forces in a theater of operations. It demonstrated the importance of having ready, well trained, and specialized units for the performance of highly technical tasks. How well we have learned these lessons will be examined in the next section.

Section Four. Engineering and Base Development in a Southwest Asia Scenario.

As mentioned earlier, the world is changing, and with it so will the expected missions of the Army. We will most likely reduce the emphasis placed on the mid- to high-intensity combat of western Europe. Instead, we will look perhaps to the greater probabilty of low- to mid-intensity conflict in the Third World. We will begin to view the Army's role as primarily that of a contingency force, ready to deploy and exercise military power in the pursuit of national objectives. That shift in mission focus will require the military engineer community to place more emphasis on support at the operational level.

A Southwest Asia scenario is used at the Command and General Staff College to teach contingency planning and execution at the operational level.[51] This scenario, augmented by lessons offered from the Normandy

study, will be the basis of my case study for the Corps of Engineers roles in base development in an austere theater of operations.

The specific scenario is the Oman exercise used in support of the School of Advanced Military Studies. In this scenario, the Peoples Democratic Republic of Yemen (PDRY) is fighting an undeclared war with the Sultanate of Oman. The PDRY has attacked Omani shipping and oil facilities. Cuban forces in the PDRY have been strengthened and Soviet military assistance to the PDRY has increased. The volatile situation between the two nations has prompted the Gulf Cooperation Council, supported by other nations, to seek the assurance of the United States for the security of the region and the uninterrupted flow of oil.[52]

The National Command Authority decided to provide the protection through the use of military force. The US Central Command was directed to implement its theater of war campaign plan for this situation. Briefly, the USCENTCOM mission is to protect the sovereignty of Oman and protect US, allied, and neutral shipping in the waters surrounding Oman. JTF OMAN is established to conduct operations in Oman. The mission of JTF OMAN is to protect the oil production infrastructure of Oman, to defeat an invasion of Oman, and to provide logistics support to Omani forces.[53]

Initial forces in the theater are elements of the US Navy. One carrier battle group and a surface action group will provide the initial combat power. The US Marine Corps will provide a forced entry capability. One Marine Eexpeditionary Brigade (MEB) is initially available for assault amphibious operations. This unit will be reinforced by two additional MEBs, a Marine Air Wing, and a forward support group. Total Marine forces number about fifty thousand. Although any Marine forces

ashore are under the operational control of the Commander, JTF OMAN, Navy forces afloat and Marine forces ashore will be self-sustaining for the purposes of base development planning.

Army forces allocated to JTF OMAN are formidable. The ground combat force is a light corps of four divisions: one airborne, one air assault, one light infantry, and one mechanized infantry. The corps' normally associated combat, combat support, and combat service support units are included. The air assault division, with its normally associated corps units, is in Egypt on a BRIGHT STAR exercise. Additionally, an Army Support Element will provide support to both JTF OMAN and other forces in the theater. Army strength totals nearly 137,000.

Air support to the theater, specifically JTF OMAN, is also powerful. Nine tactical fighter squadrons, two of them close air support, are augmented by reconnaissance and airlift squadrons. Of an estimated 35,000 Air Force personnel in the theater, less than 2,000 will be forward based in Oman; the remainder will operate out of bases in other GCC nations.

Finally, the Sultan of Oman's armed forces of 20,000 are included in JTF OMAN. These forces are under the operational command of the Commander, JTF OMAN. JTF OMAN will provide logistical support to the Omani forces as practicable.

Total US and Omani forces in Oman will number nearly 155,000. Sustaining a force of this size in the relatively austere theater of Oman will require a substantial base development plan.

To understand the concept for support, a brief overview of the concept of operations is first necessary. Ground combat is expected to be confined to the Dhofar region (see map at Appendix 1). Marines will

first establish a lodgement area in the Salalah-Raysut area into which the divisions and support elements of the corps will flow. The air assault division will begin deployment from Egypt to the Salalah area on C+2. Simultaneously, the airborne division will begin movement directly into the COMMZ. The light division will arrive by sea and air on C+7. The mechanized infantry division will arrive C+18 (D+4). The airborne division may be employed as early as D+5. JTF OMAN will establish a support base in the Muscat area on the northern coast. The airborne division will initially be the CENTCOM reserve; upon its commitment to fighting in Oman, up to two Marine MEBs will be a floating reserve. The COMMZ in Oman will extend through the northern two-thirds of the country.

At the declaration of C-Day, forces will begin movement into Oman through two main entry areas. Build-up in Oman will be rapid. As early as C+2, Army combat forces will move into the Salalah area via the Raysut port and the Salalah airfield; the lodgement will have been secured by a Marine MEB. Army support elements, along with the airborne division, will move into the Muscat area via the Seeb International Airport and the Qaboos port. The majority of forces will have arrived in Oman prior to the expected D-Day (C+14). The mechanized division will begin arriving on D+4, or C+18. The total planning populations to be supported, to include enemy prisoners of war captured after D-Day, will be over 45,000 in the Muscat area and more than 110,000 in the Salalah area (see Appendix 2).

Although combat operations are expected to be completed by D+60, it is anticpated that some US forces will remain in Oman at least to D+180 in support of peacekeeping operations and the reconstruction of the

Omani infrastructure. Given this guidance, and prior to the planning and execution of engineer support to base development, basic planning parameters must be defined. Doctrinal construction criteria will govern[54]:

-- Existing facilties will be used to the maximum extent possible.

-- Existing facilities will be modified rather than undertake new construction.

-- Austere design and construction techniques will be used.

-- US engineer troop effort will be minimized.

The construction standards for base development will be mixed. An initial standard will be instituted for theater support activites within the combat zone (0 to 6 months); this standard is characterized by austere facilities which offer immediate support to units arriving in the theater. In the support base area around Muscat, initial standards will predominate. However, some facilities in the COMMZ will be constructed to temporary standards, i.e. design life will not exceed 24 months.[55] Temporary standard facilties will only be those that enhance the efficiency of operations. All construction will be performed with a minimal amount of imported materials.

Engineer planning assumptions will be based on earlier plans made for the region.[56] For developing construction requirements, it is assumed that local skilled labor, contractors, and materials are not available. For real property requirements, it is assumed that no local facilities will be available. Although these assumptions may change during the course of the operation, they must be considered valid if the proper engineer forces and materials are to be available to the theater.

Engineer requirements in support of base development in Oman will be

directly related to the suggested criteria. In support of the deployment and build-up, port capacities are generally adequate but some work will be required in Raysut. The arrival airfields will be capable of accepting and processing the in-bound strategic lift aircraft. However, prior to the capture of the Thumrait airfield north of Salalah, the construction of heliports and a forward tactical airfield must be planned. In support of force sustainment, the ground line of communication connecting the support base in the north with the combat zone will be approximately nine hundred kilometers long. This tenuous link will require extensive rehabilitation and routine maintenence. Also, support facilities ranging from troop accommodations and POW compounds to storage and maintenenace facilties will be required to sustain the force.

Engineer requirements for each major type of construction will be discussed in detail. The scope of this study precludes a detailed engineering analysis of every specific construction requirement and the types and quatities of materials needed. However, it will provide an idea of the general requirements and considerations necessary for engineering support at the operational level.

<u>Ports and Logistics Over the Shore:</u> Ports Qaboos and Mina al Fahal at Muscat and Port Raysut near Salalah are modern ports.[57] Port Qaboos, a container and cargo port, is the best equipped in Oman, with modern support facilties and equipment. The capacity of Port Qaboos will not hinder the flow of seaborne units and equipment into the theater. Port Raysut, however, will not be capable of supporting a rapid build-up of forces in the combat zone without additional engineer effort.

The Raysut port has four berths that can accommodate the average

cargo and RO/RO vessel. The greatest depth, however, is expected to be less than 7 meters at no more than two berths. The fast support ships that will carry the equipment of the light infantry division and the mechanized division have a draft, at full load, of 11.2 meters. The maritime pre-positioning ships in the Indian Ocean have a maximum draft of 9.8 meters.[58] The majority of vessels that will carry our seaborne forces into Raysut will have to be partially off-loaded by lighter before they can be transferred to a berth. Although dredging is a viable course of action, this would not be accomplished under initial standards.

Since Raysut is expected to be easily within striking distance of PDRY aircraft, a rapid off-loading rate is needed. Engineer effort will be used to increase the rate by the construction and maintenance of landing craft ramps and beach stabilization. Stabilized hardstands in the beach area will be built to facilitate cargo transloading on shore. As time permits, additional temporary lighterage wharves will be built.

Although no specific information is available regarding the condition of the Raysut port, damage to the facilities due to enemy action must be assumed. A conservative estimate of thirty percent damage to wharves and roadways in the port area, in addition to debris removal, will require concentrated engineer effort.

The type of work required will most likely exceed the capability of the combat engineer units found in the corps. Operational engineering assets should be allocated. An engineer port construction company has the capability to conduct all of the tasks described, however, a combat heavy engineer battalion does have some of the equipment and skills required.

Airfields and Heliports: The major airfields in both the theater support base and the combat zone are capable of accepting the allocated strategic airlift daily sorties.[59] Seeb International Airport in Muscat is the best airport in Oman with complete support facilties as well as parking area for up to three C-141 squadrons. Without any additional engineer effort, the Seeb airport is the best base for the C-130 squadron supporting JTF Oman. However, there are limitations on the airfield in Salalah.

The Salalah airfield is limited in both support facilities and parking area. Due to its smaller size it can receive only ten percent of the strategic airlift capability of Seeb International. Minor engineer work at Salalah will require an expansion of parking area for an arbitrary minimum of ten C-130 aircraft (half of a full squadron). Due to the low fuel storage capacity of 85,000 gallons, a military POL pipeline connecting the Raysut port and the airfield will be built.

Two other major airfields in the combat zone should be available for use after enemy forces have been pushed toward the PDRY. Thumrait airfield, 80 kilometers north of Salalah, is capable of accepting C-5 aircraft. Manston airfield, 75 kilometers west of Salalah, can accept C-130s. It is expected that these airfields will have sustained light damage (thirty percent) to all facilties. This requires planning for construction and rehabiliation effort.

A tactical airfield in the forward area of the COMMZ will be planned for the A-10 and OV-10 squadrons that will be stationed in Oman. This airfield will be sited in a coastal area in order to facilitate aviation fuel delivery via a military pipeline. In addition to the aircraft operation areas, minimal support facilities will be constructed. These

will be for POL storage and distribution and storage for other supplies, primarily Class V.

Airfields in support of helicopter operations will be built in the combat zone. Divisional engineer battalions and the corps combat engineer battalions will be capable of constructing heliports for divisional aircraft. However, with the introduction of an air assault division and a combat aviation brigade into Oman, theater engineer assets will be required to prepare the minimum required facilities within acceptable time limits.

POL and Water Piplines: Use of military pipelines will be minimal. As mentioned above, one POL pipeline approximately fifteen kilometers long will be installed to connect the JP-4 storage tanks at Raysut with the Salalah airfield. Depending on the final selection of the forward operating airfield for tactical Air Force aircraft, one pipeline of up to thirty kilometers is planned to carry avaition fuel from a theater shuttle tanker to the airbase.

Water pipelines will be installed in the support base area. Engineers are responsibile for construction and maintenance of semi-permanent and permanent water utilities at Army fixed installions. Engineer support for water supply in the COMMZ will be limited to the supply of Army hospitals built in the support base area. All other water supply will be accomplished by quartermaster units on a supply point and unit distribution basis.[60]

Road Rehabilitation: No new road construction is anticipated in the theater. Major engineer effort will be required to rehabilitate and maintain the primary LOC between the Muscat support base and the combat zone. This LOC is estimated to be 900 kilometers long.[61]

General, full route rehabilitation work will not have to begin until D+15. By that time it can be expected that heavy traffic would have damaged significant sections of the road. The concept for execution of this roadwork will be to assign sectors of the LOC to specific engineer units which would work out of temporary, intermediate base camps along the route until the work is accomplished.

General Construction Requirements: All support units throughout the theater will provide as much protected working and living space as allowed by either TO&E or CTA. It is assumed that there will be few, if any, local Omani facilities available. All support work in the combat zone will either be performed in tentage or enclosed vans; the majority of support work in the COMMZ will be also. Although this should relieve COMMZ engineers of significant responsibility for construction, there will be some work that must be done.

General construction in the theater is divided into six types. Facilities construction is categorized as mainentance, administrative, medical and dental, troop accommodation, and POW camps. Storage areas, either covered or open, is the sixth type of construction. Below is a summary of facilities construction effort; more detailed information is in Appendix 4.[62]

Type Facilties	Basic manhours	Adjusted manhours (mh x 1.15)	CBT EN BN (Hvy) Days
Maintenance	125,747	144,609	16.4
Administrative	59,892	68,875	7.8
Medical & Dental	2,097,228	2,411,812	274.1
Troop Camps	1,269,488	1,459,911	165.9
POW Camps	233,972	269,067	30.6
Storage	40,118	46,136	4.6
TOTAL			499.4

Required maintenance and administrative facilites in the COMMZ will be minimal. A major consideration for new construction is based on future considerations for redeployment support as well as support of current operations. This type of construction will be less than five percent of the total estimated construction requirements.

The most extensive engineer effort in the COMMZ will be the construction of a hospital complex in the Muscat area. The dominant factor for in-theater hospital needs is the planned theater evacution policy of 30 days. At the peak of expected combat operations, COMMZ hospital bed requirements will exceed 6,400. In accordance with medical doctrine, 75% of the beds will be in general hospitals (1,000 beds each); the remaining 25% will be equally split between field and station hospital units.[63] Hospital construction is 55% of the estimated COMMZ construction requirements.

Construction of troop accommodations will comprise 33% of the facilties requirements. Troop camps are constructed in anticipation of support for redeployment. This estimate is based on providing housing for only 66% of a planned population of nearly 40,000; remaining troops in the COMMZ will be housed in tents. Troop facilities will be austere. Housing will be tentage over constructed frames and flooring. The only running water provided will be for shower facilities (planned to allow one shower per week per person) and mess halls. Troop camps will have minimal administrative, parking, and maintenance areas. Small camps are planned at intervals along the main supply route linking the COMMZ base area to the combat zone.

Provisions for the security and control of enemy prisoners of war must be made. Although minor holding facilties will be constructed by

the divisions and corps in the combat zone, the major POW compound for the theater will be in the Muscat area. Minimal facilities will have been constructed by D-Day.

Construction of storage areas must be accomplished to support sustainment of the force. It is assumed that only 25% of prepared storage space in port areas may be available for JTF OMAN use. Although a significant effort is not required, the completion of storage facilities for supplies and equipment will be critical to the early success and long-term sustainment of JTF OMAN.

Engineer services are also required in the theater. Facility engineer teams will be needed to operate the hospital, administrative, and troop accommodations in the COMMZ. Although most electrical power will be produced by tactical generators, engineer powerline teams may be needed to provide power to hospitals by tapping into the Oman commercial power grid. Engineer well drilling teams may be employed to locate and develop underground water sources in the interior of Oman, especially at selected intermediate troop camp facilities along the main supply route. Finally, engineers must plan for refuse disposal in all areas of the theater; at four pounds of refuse per man per day, this will entail significant hauling and landfill operations.[64]

From this brief, non-technical discussion of requirements it is evident that engineers will play major role in base development in the theater. The question remains to be answered: Can the current engineer active force structure meet the task?

Section Five. **Analysis of Engineer Requirements and Support.**

Engineer tasks in support of base development in the Oman scenario are various and complex. The allocated engineer forces for this scenario will be taxed heavily to accomplish all that is required. In fact, this operation may be placed at risk due to the limited number of operational level engineer units available in the active Army force structure today.

The engineer units allocated for this scenario were organized into two major commands, excluding the engineer battalions found in each division. The number of engineer soldiers in each of the commands suggests the following organization[65]:

Engineer Brigade (Corps)	Available: AC/CONUS	AC/OCONUS	RC
1 - HQ, Engineer Brigade (Abn Corps)	1	-	-
2 - Combat Engineer BN (Abn)	2	-	-
1 - Combat Engineer BN (Light)	-	-	1
1 - EN BN (Cbt Hvy)	7	7	32
1 - Combat Support Equipment CO	2	3	21
1 - Light Equipment CO (Abn)	2	-	-
Engineer Brigade (Theater Army)			
1 - HQ, Engineer Brigade (TA)	-	-	1
2 - HQ, Engineer Group	2	1	17
6 - EN BN (Cbt Hvy)	7	7	32
2 - EN CO, Construction Spt	1	-	9
1 - EN CO, Port Construction	1	-	2
1 - EN CO, Pipeline Construction	1	-	3
2 - EN CO, Dump Truck	-	-	4
1 - Engineer Well Drilling Team	2	-	8
20 - Engineer Team, Firefighting	1	-	19
2 - Engineer Team, Water Truck	2	-	-
1 - Engineer Team, Real Estate	-	-	3
5 - Engineer Powerplant Ops Team	-	-	2
2 - Engineer Powerline Team	-	-	2

As a basic analytical unit for scaling engineer effort, I have selected the Engineer Battalion (Combat Heavy). This type of battalion has a generally well-rounded capability for construction of both

vertical and horizontal construction (e.g., facilties are vertical, roads and airfields are classified as horizontal). It is the basic unit to theater level engineer commands, brigades, and groups.

With the numerous types of engineer battalions in the theater, each having a specific capability for construction, a common unit of measure is needed to aggregate total engineer construction capability. Since the combat heavy battalion is the basic construction unit, all other battalions will be related to it[66]:

Type Battalion	EN BN (Cbt Hvy) Equivalant	Total In-Theater Equivalant
EN BN (Cbt Hvy)	1.0	7.0
CBT EN BN (Abn)(Corps)	.4	.8
CBT EN BN (Lt)(Corps)	0.0	0.0
CBT EN BN (Air Aslt Div)	.3	.3
CBT EN BN (Abn Div)	.6	.6
CBT EN BN (Lt Inf Div)	0.0	0.0
CBT EN BN (Hvy Div)	.4	.4
Maximum Available EN BN (Cbt Hvy) Equivalents:		9.1

From the above table it should be understood that light engineer battalions in the corps brigade and the light infantry division have negligible capability for construction work. Also, the airborne division engineer battalion is augmented with an airborne light equipment company.

The table also does not reflect the unique organization and specialized work done by separate engineer companies. The port construction and pipeline construction companies each have their own unique capabilities. The engineer equipment companies will be used to augment all other units.

Engineer forces will enter the theater over an extended period. The first engineer units will be those organic to divisions and therefore

very limited in their capability to begin the work necessary to establish the theater infrastructure. The heavier engineer units will begin a relatively slow build-up and will not be fully established in the theater until about C+13, one day prior to D-Day. This is primarily due to the extended arrival of the sealift carrying the engineers' equipment.

Relating the engineer requirements to in-theater capability can best be summarized by the following table:

Cumulative Engineer Battalion (Cbt Hvy)-Day Requirements vs Capability
(Numbers represent EN BN (Cbt Hvy)-Days)

	C+5	C+10	D-Day	D+5	D+10	D+20	D+40
Airfields:							
Construction			18.1	18.1	18.1	18.1	18.1
Rehab.					4.5	4.5	4.5
Heliports:	18.5	85.9	96.2	105.0	105.0	105.0	105.0
Facilities:							
Maintenenace			16.4	16.4	16.4	16.4	16.4
Administrative			7.8	7.8	7.8	7.8	7.8
Medical	48.5	97.0	176.1	176.1	238.6	274.1	274.1
Troop Camps	55.3	110.6	165.9	165.9	165.9	165.9	165.9
POW Camps			15.3	15.3	15.3	30.6	30.6
Storage	4.6	4.6	4.6	4.6	4.6	4.6	4.6
MSR Rehab						10.0	46.2
Cumulative EN BN Days Required	**126.9**	**445.1**	**509.2**	**576.2**	**627.0**	**627.0**	**673.2**
Cumulative EN BN Days Available	**3.1**	**17.6**	**49.4**	**93.3**	**138.8**	**229.8**	**411.8**
Shortfall (EN BN Days)	**123.8**	**427.5**	**459.8**	**482.9**	**488.2**	**397.7**	**261.4**

Comparison of the bottom three lines of the table reveals a major shortfall in engineer capability. Assuming that the engineers'

capability will not be degraded during the time in Oman, all of the desired construction would be accomplished no earlier than D+69. However, also assuming that divisional engineer battalions and corps combat engineer battalions will concentrate on tactical engineering tasks, all base development support requirements could not be completed by the heavy engineer battalions earlier than D+93. By that time, the fighting may have been over and the redeployment of forces begun.

Although not shown on the above table, the two other major construction assets are also affected. The estimate for port rehabilitation and new construction work is 22 days of effort by the port construction company. Although early work cannot be done to facilitate offloading of the initial sealift into Raysut, enough work will most likely be completed to speed the debarkation of the heavy division arriving on D+4. The pipeline construction company should meet the construction requirements in the combat zone in accordance with the expected tactical plan. However, the early need for waterlines to the hospitals in the COMMZ will place a strain on that unit's resources. Appendix 3 provides a detailed estimate of the work expected of these two companies.

The table summary prompts an analysis of the engineers' capability to support base development in the theater with regard to the criteria for success suggested earlier. Each will be discussed in turn.

Engineers must maximize capacities of airfields and ports on the first day of deployment. There exists in the active force adequate engineer units to support the deployment of the Oman task force. The port construction capability, along with vertical and horizontal construction capability, are available in the active component on C-Day

for deployment to the theater. The issue regarding their timely employment is their arrival in the theater.

The first Army engineers in the theater are tactical engineer battalions. They possess very limited capabilities to support improvements to airfields and seaports. The first specialized engineer units capable of improving the Raysut port facilities will arrive no earlier than the first major unit arriving by sea on C+8. The air assault divisional engineer battalion that closes first into the Salalah area may be used to develop LOTS sites in the area; however, its use must be weighed against the requirements for combat engineer tasks. Another Army asset may be the airborne light equipment company in the corps. In any case, the Army would have difficulty getting the right type of units into the theater early due to the size of the equipment found in those units.

Engineers must meet minimal construction requirements to support a rapid build-up in the combat zone and COMMZ. Present active component engineer units could not support the build-up of personnel and equipment in the Oman theater prior to D-Day. There would exist a major shortfall of capacity in all areas of construction in support of base development. There are not enough combat heavy engineer battalions in the active force to significantly influence the rate of support required by the planned build-up. This will be discussed in more detail below.

Engineers must meet all planned construction requirements in the theater to sustain the total force. This point of the criteria requires the most detailed discussion. The force will reach maturity upon the arrival of the heavy division by sea on D+4 (C+18). It is expected by that time it will be committed directly into combat. The airborne

division will be quickly committed. At that time, between D+5 and D+10, the total force will see the beginning of a higher intensity of combat. By D+20 of this scenario, the COMMZ support base should be fully operational.

The allocated theater engineer force from the active component cannot accomplish the estimated construction requirements by D+20. Assuming that all CONUS-based active combat heavy engineer battalions were deployed, this scenario would deplete the active Army's ready construction force. The port construction company is the only one on active duty as is the pipeline construction company.[67] The engineer brigade (theater army) headquarters, along with both dump truck companies, one construction support company, and the majority of the technical engineer teams, would have to be activated from the reserve components.[68] No additional significant construction capability could be brought to bear in the theater unless forces were either deployed from other theaters (Europe or Korea) or reserve units were activated.

More units may not be the best solution. For example, the arrival of three additional active component combat heavy engineer battalions from Europe by D-Day would allow completion of all required D+20 engineer tasks by D+58. To complete all estimated D+20 engineer requirements, 42 combat heavy battalions would have to be ready for employment in the theater on C+5. That number, providing that even the shipping is available, would use all reserve component battalions, the CONUS battalions, and three battalions from other theaters.[69] The solution must be found elsewhere.

For this scenario, the most obvious solution is to reduce the construction requirements. Since the construction estimates for the

support of this hypothetical scenario are based on minimal needs of the forces in the theater, it would not be easy to selectively cut any engineer effort without having heavy impacts on sustainment of the force.

Each individual type of engineer effort should be examined separately for the best answer to the problem. For example, the thirty day evacuation policy for casualties in the COMMZ could be reduced. This would decrease the need for hospital construction in the COMMZ, the greatest single demand for engineer work. Likewise, the combat zone policy could be increased from seven to ten days; this would place more casualties in forward field hospitals that require less effort to set up and maintain. Another method to reduce hospital construction in the COMMZ would be the employment of the Navy's two 1,000 bed hospital ships.[70] Each aspect of engineer work should be weighed against the overall requirements of the theater support base.

It may be possible to delay the commitment of forces to combat. This could extend the arrival of forces into the theater and thereby stretch out the required engineer effort over a longer period.

A viable solution in this scenario would be a combined engineer effort by all services. In port construction, the Navy is responsible for major dredging, major salvage operations, and offshore construction. If their mission was extended to include basic rehabilitation of over-water facilties, it would reduce an initial demand for Army engineer port construction effort. In LOTS operations, an extension of the Navy's responsibilities from the waterline to two hundred meters inland would assist the Army's task of providing access and egress. Commitment of Air Force engineers for assistance in the rehabilitation of major

airfields would also reduce the total requirements for the theater Army engineer force.

Could our active Army engineer forces meet the tasks demanded of them in the Oman scenario? As an engineer officer, I firmly believe that all professionals in our active duty engineer organizations would certainly say that they are up to the tasks. The strong sense of commitment among the Corps of Engineers' officers and soldiers would demand that they do their best. However, the sheer volume of the work required in a relatively short time would swamp the capabilities of today's active Army engineer team.

Section Six. Conclusions.

Base development in a third world austere theater will be a necessary step in any future campaign plan. Army engineers are major contributors to this plan. A successful campaign will depend on the early arrival of the right engineer forces in the theater.

Operational level engineering missions do not stand alone. Every aspect of the theater civil engineer support plan is heavily dependent on accurate input from all other branches of the Army and, in some cases, from other services. The hospital example in the preceding section is an excellent illustration of weighing engineer capabilities against expections.

The theater commander will have to make decisions regarding the employment of engineers from all of his supporting services. Marine Corps construction battalions and engineer groups, along with Air Force Red Horse engineer squadrons, may have to perform tasks that exceed t' r usual methods of operations until the arrival of more specialized

Army engineer units.

From an operational sustainment perspective, military engineering in support of a campaign plan is inadequate if specific plans are considered only for the initial phases. Engineer plans with only a general concept for requirements in the latter phases may place the total force at a sustainment risk.[71] Engineers must plan for all contingencies within a campaign, develop the force list required, deliver construction materials on time and in the right place, and put the right unit on the ground to complete the task on time. The OVERLORD COMMZ engineer plan is the model for this lesson.

The Corps of Engineers is limited in its ability to project a light equipment force rapidly. There are only two light engineer equipment companies on the active troop list. The formation of additional light equipment companies, possibly augmented with selected engineer teams, and assigned to engineer groups either in CONUS or in other theaters, would give the Army a rapidly deployable construction capability that could fit a variety of situations.

The active Army engineer force would be hard-pressed to meet the requirements of a contingency such as the Oman scenario. The capability exists in the active components but a deployment on the scale of the scenario depicted would strip the Army of its most ready construction asset. Nearly all multiple construction assets would be deployed to one region of the world for one contingency. It would then fall to the reserve component engineers to give depth to our overall ability to meet other simultaneous crises.

In summary, the criteria suggested are valid for engineer support at the operational level. However, the Oman scenario leads me to the

conclusion that the active component engineer force cannot support a rapid contingency operation that would require a major base development effort. Heavy engineer forces and specialized engineer construction units are not capable of rapid and early deployment, and therefore cannot provide the timely support for the deployment and build-up of the total force. Also, the limited number of heavy construction forces in the active Army will not be able to meet the expected high demands for construction support in an austere theater.

Section Seven. Recommendations.

If the Army is to become a force capable of responding to a variety of contingencies throughout the world, then the engineer community must change accordingly. Steps must be taken to make the Army a more capable engineer force with regard to the support of contingency force deployment, build-up, and rapid base development. More construction capability must be placed in the active force. Additional combat heavy battalions or light equipment companies as mentioned above in the active force would be a positive step in supporting the Army of the future.

To support force deployment, methods must be developed to move critical construction assets into a contingency theater quickly. This can either be accomplished through two methods: altering force structure or prepositioning resources. It may be feasible to create light engineer equipment construction battalions or separate companies from the manpower spaces lost through the deactiviation of active forces in the next few years. Units of this type should be more than 90% deployable by C-141 and C-17 aircraft.

Prepositioning is perhaps a more realistic option, and one that

would also strengthen the engineers' ability to support a build-up phase and the more complex base development phase. Construction equipment of battalions scheduled for deactivation could be stored either in land based sites or on board ships of the Maritime Prepositioning Force. Engineer equipment and construction material packages afloat or stored in a theater, near where it is expected to be used, would greatly enhance the sustainment of the total force.

Engineer training and doctrine must also be modernized to support the changing missions of the Army. Developing "jointness" in the military engineering community must be emphasized in the future. Engineer planning for operational campaigns cannot be a single service responsibility. Engineers of all services must be capable of mutual support in an austere theater of operations, especially during the build-up phase. This requires common engineer language and cross-training at the senior engineer officer level in all services. It also requires that unified commands develop detailed engineering estimates and plans for all phases of contingency plans that are executed under the supervision of a senior theater engineer.

Finally, it must be recognized within the engineer community that more training is necessary for senior engineer commanders and staff officers in support of the operational level of war. Army engineer field grade officers should have an opportunity to develop civil engineer support plans at the operational level, employing not only resources of their own service but those of the Navy, Marines, and Air Force. The goal of the US Army Engineer School should be to provide this technical operational-level training to all engineer field grade officers in TO&E units that support the Army in the field.

Endnotes

[1]Baron de Jomini, *The Art of War*: 87-88.

[2]FM 100-15, *Corps Operations*: 1-2.

[3]*Ibid*: 1-3.

[4]James J. Schneider, *Theoretical Paper No. 3*: 23.

[5]FM 31-82, *Base Development*: 2-2.

[6]JCS Pub 3, *Joint Logistics Policy and Guidance (U)* (July 79): 6-16.

[7]FM 5-100, *Engineer Combat Operations*: 12.

[8]*Ibid*.

[9]FM 100-5, *Operations*: 65.

[10]FM 5-100: 9-10.

[11]JCS Pub 3, Chapter 6 provides detailed joint policy regarding construction responsibilities.

[12]Each chapter of FM 5-104 addresses a specific type of general engineering. As a part of the discussion in each chapter, there is a breakdown of the responsibilities for types of engineer work by each service.

[13]FM 100-16, *Support Operations: Echelons Above Corps*: 9-14

[14]Primary source is Appendix A of FM 5-100. The basis of allocation for engineer units is extracted from the US Army Engineer School TAA 96 Allocation Rules (as of 29 Dec 89).

[15]Gordon A. Harrison, *Cross-Channel Attack*: 1.

[16]Omar N. Bradley, *A General's Life*: 254.

[17]Russell F. Weigley, *Eisenhower's Lieutenants*: 70.

[18]Alfred M. Beck, *et al*, *The Corps of Engineers: The War Against Germany*: 282.

[19]Roland G. Ruppenthal, *Logistical Support of the Armies, Volume I*: 288.

[20]Stephen P. Peterson, "Operational Sustainment: The Impact of Critical Decisions Upon Operational Design:" 17.

[21]*Ibid*: 18.

[22]European Theater of Operations, US Army (Forward Echelon), "Communications Zone Plan," dated 14 May 1944 (hereafter referred to as ETO COMMZ Plan): Part A, COMMZ Troop Priority List, to Appendix I, Troops.

[23]C.R. Moore, *Final Report of the Chief Engineer, ETO*: 130.

[24]William A. Carter, Jr., *Employment and Staff Procedures of Engineers with Division, Corps, and Army*: 73.

[25]Beck, *et al*: 283.

[26]Blanche D. Coll, Jean E. Keith, and Herbert H. Rosenthal, *The Corps of Engineers: Troops and Equipment*: 457-458, and Beck, *et al*: 296.

[27]*Ibid*: 277-278.

[28]Moore: 65-66.

[29]ETO COMMZ Plan: Annex 8, Communications Zone Engineer Plan, page 15.

[30]Ruppenthal: 344.

[31]*Ibid*: 397 and 401.

[32]*Ibid*: 285.

[33]*Ibid*: 297

[34]Moore: 271.

[35]*Ibid*: 273-274.

[36]*Ibid*: 345-346.

[37]Ruppenthal: 545.

[38]ETO COMMZ Plan: Annex 8, Communications Zone Engineer Plan, page 17.

[39]Moore: Appendix 31-A. A total single track-mileage distance of 1906 miles was calculated by adding all completed track sections between all rail centers in the American area of operations between the coast of Normandy and the Seine River.

[40]Ruppenthal: 314.

[41]Moore: 288.

[42]*Ibid*: 289-290.

[43]Ruppenthal: 323.

[44]Moore: Appendix 33-C-1.

[45]Beck, *et al*: 405.

[46]ETO COMMZ Plan: Annex 8, Communications Zone Engineer Plan, page 16.

[47]Moore: Extracted from Appendices 34, 35, 36, and 37.

[48]*Ibid*: Extracted from Appendix 39.

[49]*Ibid*: 362-363.

[50]Weigley: 107.

[51]Two courses at the Command and General Staff College use an Omani situation for training in the operational level of war: P157, "Operational Warfighting" of the Command and General Staff Officers Course, and the "USCENTCOM Exercise" of the School of Advanced Military Studies for both the Advanced Operational Studies Fellowship and the Advanced Military Studies Program.

[52]School of Advanced Military Studies (SAMS), "USCENTCOM Exercise 1990": Tab A, page 2.

[53]*Ibid*: Theater of War Campaign Plan (USCENTCOM 90-1), page 5.

[54]FM 5-104: 3.

[55]*Ibid* and FM 101-10-1/2, *Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors (Vol 2)*: page 1-31.

[56]Headquarters, XVIII Airborne Corps, *ARFOR OPLAN 2-80 - POSITIVE LEAP 80 (Declassified 9 Oct 86)*: pages D-5-1 thru D-5-2.

[57]Port data for all estimates regarding port requirements are derived from four sources:

a. Defense Mapping Agency, *World Port Index (10th edition)*: 172-173.

b. Patrick Hicks, *Jane's Containerisation Directory, 1989-90*: 52.

c. Command and General Staff Officers' Course program of instruction for Course P157, "Operational Warfighting," Lesson 5, Annex B (Port Data).

d. SAMS, USCENTCOM Exercise logistics estimate.

[58]Norman Polmar, *Ships and Aircraft of the U.S. Fleet (14th Edition)*: 280-293.

[59]Airfield data for planning is based on two sources:

a. Command and General Staff Officers' Course program of instruction for Course P157, "Operational Warfighting," Lesson 5, Annex C (Airfields).

b. SAMS, USCENTCOM Exercise logistics estimate.

[60]FM 5-104: 93. Quartermaster units have the responsibility for the purification and distribution of water to deployed forces. The Corps of Engineers retains responsibility for exploration and development of subsurface and surface water sources and the supply of water to fixed Army installations.

[61]Estimate of road distance from Defense Mapping Agency map, Series ONC, sheet J-7 (scale 1:1,000,000), edition 8-GSGS (82).

[62]FM 101-10-1/2: Section 1-27. The basic manhours are adjusted by an environmental factor. In the Oman scenario a 1.15 factor is used for the desert conditions (page 1-30).

[63]FM 100-16: 8-5.

[64]FM 101-10-1/2: 1-43.

[65]The organization list is based on several sources. The basic planning strengths were specified in the SAMS USCENTCOM SWA Exercise 1990; given strengths were 5,846 for the theater engineer brigade and 2,957 for the corps engineer brigade. Types of units, and breakdown by components, were derived from the US Army Engineer School's TAA 96 Allocation Rules (as of 26 Dec 89) and the TAA 96 Force Program Review. As a check on engineer unit strengths, Appendix A, FM 5-104 was supplemented by Chapter 3, FM 101-10-2.

[66]Derived from FM 5-330, page 11-9.

[67]USAES TAA 96 Allocation Rules. The only active duty port construction company is based at FT Eustis, VA.

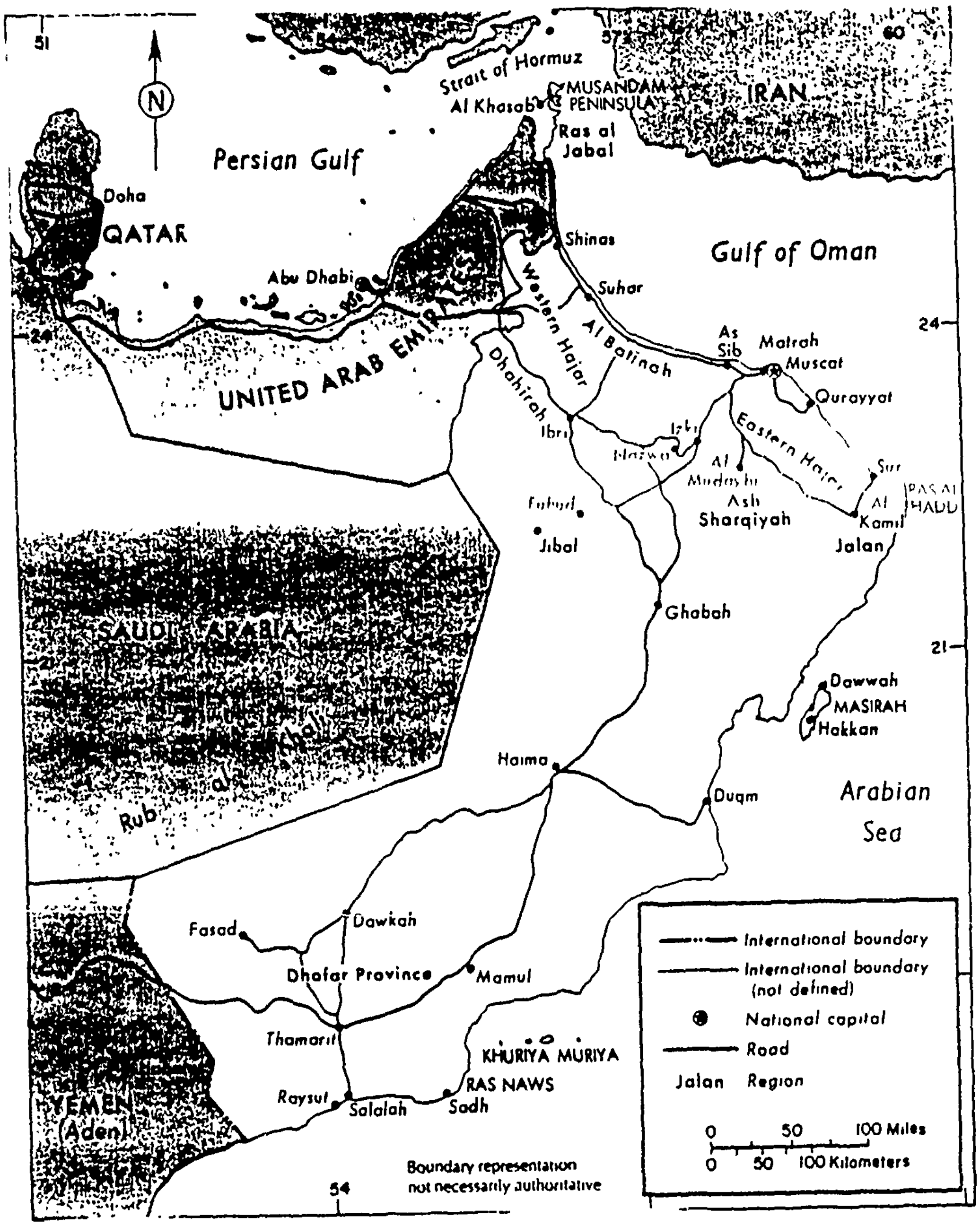
[68] *Ibid.*

[69] *Ibid.*

[70]Polmar: 277-278.

[71]After Peterson: 34.

Appendix 1. Map of Oman.



Map from *Persian Gulf States Country Studies*, p.314.

Appendix 2. Theater Population Estimates.

		C+5	C+10	D-Day C+14	D+5 C+19	D+10 C+24	D+15 C+29
Army	Muscat	9,943	24,694	52,608	52,608	39,638	39,638
	Salalah	16,627	60,363	69,656	84,339	97,309	97,309
USAF	Muscat	600	600	600	600	600	600
	Salalah	800	800	800	800	800	800
USN ashore	Muscat	1,700	1,700	1,700	1,700	1,700	1,700
Omani* Forces	Salalah	20,000	18,000	16,100	14,100	12,600	11,300
EPW**	Muscat				200	1,700	3,200
	Salalah			300	1,000	1,000	1,000
Total Forces	Muscat	12,243	26,994	54,908	55,108	43,638	45,138
	Salalah	37,427	79,163	86,856	100,239	111,709	110,409
	Theater Total	49,670	106,157	141,764	155,347	155,347	155,547

*Decrease in Omani totals due to losses calculated at 2.2%/day.

**EPW rate calculated at .00367/day x enemy strength. Enemy strength based on 50,000 PDRY and 32,700 Cuban forces.

TAB 1, Troop List, to APPENDIX 2, Theater Population Estimates.

	Deployment of: Percentage	by:	Personnel Air/Sea	Equipment Air/Sea
Army Forces				
HHC, Corps	381		100/ 0	100/ 0
Light Infantry Division	10,979	C+8	99/ 1	0/100
Mechanized Division	17,068	C+18	99/ 1	0/100
Air Assault Division	14,416	C+4	100/ 0	100/ 0
Airborne Division	12,970	C+2	100/ 0	100/ 0
Corps Aviation Brigade	3,400		98/ 2	30/ 70
Corps Artillery	7,788		98/ 2	60/ 40
ADA Brigade	2,486		98/ 2	30/ 70
Chemical Brigade (Corps)	1,722		98/ 2	0/100
Engineer Brigade (Corps)	2,957		96/ 4	0/100
MI Brigade (Corps)	1,609		98/ 2	20/ 80
LRSC (Corps)	182		100/ 0	100/ 0
Military Police BDE (Corps)	1,293		95/ 5	30/ 70
Signal Brigade (Corps)	2,403		98/ 2	70/ 30
Corps Support Command	12,175	C+5	98/ 2	50/ 50
Total Army Corps	**91,829**			
HHC, Army Support Element	300	C+5	100/ 0	100/ 0
Special Forces Group	1,385	C+1	100/ 0	100/ 0
Ranger Battalion	604	C+1	100/ 0	100/ 0
ADA Battalion (TA)	798		98/ 2	25/ 75
Command Aviation Company	97		100/ 0	100/ 0
Chemical Battalion (TA)	852		98/ 2	0/100
Engineer Brigade (TA)	5,846		95/ 5	0/100
MI Brigade (OPCON)	2,862		98/ 2	0/100
Signal Brigade (OPCON)	1,279		98/ 2	25/ 75
Signal Med Operations Company	138		98/ 2	0/100
TA Support Group	3,970		98/ 2	0/100
Area Support Group (Lt Corps)	2,467		98/ 2	10/ 90
Area Support Group (Lt Corps)	2,678		98/ 2	10/ 90
Petroleum Group	2,390	C+5	98/ 2	10/ 90
Ammunition Group	2,962	C+5	98/ 2	10/ 90
Transportation Terminal Group	6,923	C+5	98/ 2	20/ 80
Trans Motor Transport Group	3,371		98/ 2	0/100
Medical Group	3,615	C+5	98/ 2	0/100
Aircraft Maintenance Battalion	586		98/ 2	0/100
Air Traffic Control Battalion	100		100/ 0	100/ 0
Graves registration Battalion	236		90/ 10	30/ 70
P&A Battalion	1,057	C+5	98/ 2	5/ 95
PSYOP/Civil Affairs Battalion	400		100/ 0	100/ 0
EOD Detachment	57		0/100	0/100
Finance Organization	95		98/ 2	0/100
TAMCA(-)	25		100/ 0	100/ 0
TAMMC(-)	25		100/ 0	100/ 0
Total ASE	**45,118**			
Total Army Forces	**136,947**			

Marine Forces

1 MEU	2,506	C+2	0/100	0/100
1 MEB (less MEU)	13,164	C+2	0/100	0/100
1 MEB	15,670	C+7	0/100	0/100
1 MEB	15,670	C+14	100/ 0	10/ 90
1 MAW	1,600	C+14	100/ 0	60/ 40
1 Force Service SPT Grp	1,800	C+12	50/ 50	50/ 50
Total Marine Forces	**50,410**			

Air Forces

1 Tac Fighter Squadron (F-4E)		C+5	100/ 0	100/ 0
1 Tac Fighter Squadron (F-4G)		C+5	100/ 0	100/ 0
2 Tac Fighter Squadrons (F-15C)		C+5	100/ 0	100/ 0
3 Tac Fighter Squadrons (F-16)		C+5	100/ 0	100/ 0
2 Tac Fighter Squadrons (A-10)		C+5	100/ 0	100/ 0
1 Tac Recon Section (RF-4C)		C+5	100/ 0	100/ 0
1 Tac Air Spt Squad (OV-10A)		C+5	100/ 0	100/ 0
1 Tac Airlift Squadron (C-130H)		C+5	100/ 0	100/ 0
1 Special Operations Wing		C+1	100/ 0	100/ 0

Naval Forces

Naval personnel ashore	1,700			
1 Carrier Battle Group		C-Day	0/100	0/100
1 Surface Action Group		C-Day	0/100	0/100
1 Underway Replenishment Grp		C-Day	0/100	0/100
1 Amphibious Group		C-Day	0/100	0/100
1 Maritime Preposit Squadron		C+3	0/100	0/100
1 Carrier Battle Group		C+10	0/100	0/100
1 Surface Action Group		C+10	0/100	0/100

TAB 2, Estimated Buildup, to APPENDIX 2, Theater Population Estimates.

Army Forces		C+1	C+2	C+3	C+4	C+5
HHC, Corps	381	60	250	381	381	381
Light Infantry Division	10,979			150	150	150
Mechanized Division	17,068					
Air Assault Division	14,416			100	2700	5300
Airborne Division	12,970		6970	8970	10970	12970
Corps Aviation Brigade	3,400			100	100	100
Corps Artillery	7,788		100	100	600	600
ADA Brigade	2,486		50	300	600	600
Chemical Brigade (Corps)	1,722					
Engineer Brigade (Corps)	2,957		100	200	330	500
MI Brigade (Corps)	1,609		100	100	100	250
LRSC (Corps)	182	182	182	182	182	182
Military Police BDE (Corps)	1,293		100	250	400	400
Signal Brigade (Corps)	2,403		600	600	600	600
Corps Support Command	12,175	100	250	750	800	800
Total Army Corps In Country:		**342**	**8702**	**12183**	**17913**	**22933**
HHC, Army Support Element	300					300
Special Forces Group	1,385	1385	1385	1385	1385	1385
Ranger Battalion	604	604	604	604	604	604
ADA Battalion (TA)	798					
Command Aviation Company	97					97
Chemical Battalion (TA)	852					
Engineer Brigade (TA)	5,846					100
MI Brigade (OPCON)	2,862					100
Signal Brigade (OPCON)	1,279					400
Signal Med Operations Company	138					138
TA Support Group	3,970					
Area Support Group (Lt Corps)	2,467					50
Area Support Group (Lt Corps)	2,678					50
Petroleum Group	2,390					100
Ammunition Group	2,962					100
Transportation Terminal Group	6,923					50
Trans Motor Transport Group	3,371					100
Medical Group	3,615					
Aircraft Maintenance Battalion	586					
Air Traffic Control Battalion	100					
Graves registration Battalion	236					
P&A Battalion	1,057					
PSYOP/Civil Affairs Battalion	400					
EOD Detachment	57					
Finance Organization	95					
TAMCA(-)	25					
TAMMC(-)	25					
Daily Increase/Decrease:		2331	8360	3481	5730	6605
Total Forces In-Country:		2331	10691	14172	19902	26570

TAB 3, Estimated Buildup, to APPENDIX 2, Theater Population Estimates.

Army Forces		C+6	C+7	C+8	C+9	C+10
HHC, Corps	381	381	381	381	381	381
Light Infantry Division	10,979	4100	6000	8000	10769	10979
Mechanized Division	17,068					400
Air Assault Division	14,416	7930	10500	14416	14416	14416
Airborne Division	12,970	12970	12970	12970	12970	12970
Corps Aviation Brigade	3,400	1200	1400	1600	3300	3400
Corps Artillery	7,788	2000	3000	4530	7638	7788
ADA Brigade	2,486	1200	1800	1800	1800	1800
Chemical Brigade (Corps)	1,722	60	60	200	400	600
Engineer Brigade (Corps)	2,957	1000	2900	2900	2900	2957
MI Brigade (Corps)	1,609	250	800	800	1280	1609
LRSC (Corps)	182	182	182	182	182	182
Military Police BDE (Corps)	1,293	400	500	750	900	1293
Signal Brigade (Corps)	2,403	600	1200	1500	1800	2403
Corps Support Command	12,175	1000	2000	4000	6000	12175
Total Army Corps In Country:		**33273**	**44493**	**54029**	**64736**	**73353**
HHC, Army Support Element	300	300	300	300	300	300
Special Forces Group	1,385	1385	1385	1385	1385	1385
Ranger Battalion	604	604	604	604	604	604
ADA Battalion (TA)	798	600	600	600	600	600
Command Aviation Company	97	97	97	97	97	97
Chemical Battalion (TA)	852					
Engineer Brigade (TA)	5,846	100	100	150	1200	1300
MI Brigade (OPCON)	2,862		100	100	100	250
Signal Brigade (OPCON)	1,279	650	650	800	800	800
Signal Med Operations Company	138	138	138	138	138	138
TA Support Group	3,970			100	100	200
Area Support Group (Lt Corps)	2,467	50	50	200	200	500
Area Support Group (Lt Corps)	2,678	50	50	200	200	200
Petroleum Group	2,390				100	600
Ammunition Group	2,962		50	500	500	1000
Transportation Terminal Group	6,923		100	100	500	1200
Trans Motor Transport Group	3,371		100	100	500	1200
Medical Group	3,615			600	600	1200
Aircraft Maintenance Battalion	586			100	100	300
Air Traffic Control Battalion	100	100	100	100	100	100
Graves registration Battalion	236					80
P&A Battalion	1,057		50	100	100	100
PSYOP/Civil Affairs Battalion	400	100	100	100	100	100
EOD Detachment	57					
Finance Organization	95					
TAMCA(-)	25		25	25	25	25
TAMMC(-)	25		25	25	25	25
Daily Increase/Decrease:		**10877**	**11570**	**11336**	**12357**	**12347**
Total Forces In-Country:		**37447**	**49017**	**60353**	**72710**	**85057**

TAB 4, Estimated Buildup, to APPENDIX 2, Theater Population Estimates.

Army Forces		C+11	C+12	C+13	D-Day C+14	D+1 C+15
HHC, Corps	381	381	381	381	381	381
Light Infantry Division	10,979	10979	10979	10979	10979	10979
Mechanized Division	17,068	400	400	400	2400	4400
Air Assault Division	14,416	14416	14416	14416	14416	14416
Airborne Division	12,970	12970	12970	12970	12970	12970
Corps Aviation Brigade	3,400	3400	3400	3400	3400	3400
Corps Artillery	7,788	7788	7788	7788	7788	7788
ADA Brigade	2,486	1800	1800	2430	2486	2486
Chemical Brigade (Corps)	1,722	600	600	1700	1722	1722
Engineer Brigade (Corps)	2,957	2957	2957	2957	2957	2957
MI Brigade (Corps)	1,609	1609	1609	1609	1609	1609
LRSC (Corps)	182	182	182	182	182	182
Military Police BDE (Corps)	1,293	1293	1293	1293	1293	1293
Signal Brigade (Corps)	2,403	2403	2403	2403	2403	2403
Corps Support Command	12,175	12175	12175	12175	12175	12175
Total Army Corps In Country:		73353	73353	75083	77161	79161
HHC, Army Support Element	300	300	300	300	300	300
Special Forces Group	1,385	1385	1385	1385	1385	1385
Ranger Battalion	604	604	604	604	604	604
ADA Battalion (TA)	798	600	798	798	798	798
Command Aviation Company	97	97	97	97	97	97
Chemical Battalion (TA)	852	50	50	840	852	852
Engineer Brigade (TA)	5,846	4000	5000	5846	5846	5846
MI Brigade (OPCON)	2,862	500	1000	2000	2862	2862
Signal Brigade (OPCON)	1,279	1279	1279	1279	1279	1279
Signal Med Operations Company	138	138	138	138	138	138
TA Support Group	3,970	600	1200	3970	3970	3970
Area Support Group (Lt Corps)	2,467	1000	2460	2467	2467	2467
Area Support Group (Lt Corps)	2,678	200	2400	2678	2678	2678
Petroleum Group	2,390	1000	2300	2390	2390	2390
Ammunition Group	2,962	1500	1800	2800	2962	2962
Transportation Terminal Group	6,923	1600	4600	6923	6923	6923
Trans Motor Transport Group	3,371	1600	1600	2600	3371	3371
Medical Group	3,615	2400	2400	2400	3600	3615
Aircraft Maintenance Battalion	586	300	586	586	586	586
Air Traffic Control Battalion	100	100	100	100	100	100
Graves registration Battalion	236	80	236	236	236	236
P&A Battalion	1,057	300	300	500	1057	1057
PSYOP/Civil Affairs Battalion	400	100	390	400	400	400
EOD Detachment	57		50	57	57	57
Finance Organization	95		90	95	95	95
TAMCA(-)	25	25	25	25	25	25
TAMMC(-)	25	25	25	25	25	25
Daily Increase/Decrease:		8279	11430	11556	5942	2015
Total Forces In-Country:		93336	104766	116322	122264	124279

TAB 5, Estimated Buildup, to APPENDIX 2, Theater Population Estimates.

Army Forces		D+2 C+16	D+3 C+17	D+4 C+18	D+5 C+19	D+6 C+20
HHC, Corps	381	381	381	381	381	381
Light Infantry Division	10,979	10979	10979	10979	10979	10979
Mechanized Division	17,068	8400	16900	17068	17068	17068
Air Assault Division	14,416	14416	14416	14416	14416	14416
Airborne Division	12,970	12970	12970	12970	12970	12970
Corps Aviation Brigade	3,400	3400	3400	3400	3400	3400
Corps Artillery	7,788	7788	7788	7788	7788	7788
ADA Brigade	2,486	2486	2486	2486	2486	2486
Chemical Brigade (Corps)	1,722	1722	1722	1722	1722	1722
Engineer Brigade (Corps)	2,957	2957	2957	2957	2957	2957
MI Brigade (Corps)	1,609	1609	1609	1609	1609	1609
LRSC (Corps)	182	182	182	182	182	182
Military Police BDE (Corps)	1,293	1293	1293	1293	1293	1293
Signal Brigade (Corps)	2,403	2403	2403	2403	2403	2403
Corps Support Command	12,175	12175	12175	12175	12175	12175
Total Army Corps In Country:		**83161**	**91661**	**91829**	**91829**	**91829**
HHC, Army Support Element	300	300	300	300	300	300
Special Forces Group	1,385	1385	1385	1385	1385	1385
Ranger Battalion	604	604	604	604	604	604
ADA Battalion (TA)	798	798	798	798	798	798
Command Aviation Company	97	97	97	97	97	97
Chemical Battalion (TA)	852	852	852	882	852	852
Engineer Brigade (TA)	5,846	5846	5846	5846	5846	5846
MI Brigade (OPCON)	2,862	2862	2862	2862	2862	2862
Signal Brigade (OPCON)	1,279	1279	1279	1279	1279	1279
Signal Med Operations Company	138	138	138	138	138	138
TA Support Group	3,970	3970	3970	3970	3970	3970
Area Support Group (Lt Corps)	2,467	2467	2467	2467	2467	2467
Area Support Group (Lt Corps)	2,678	2678	2678	2678	2678	2678
Petroleum Group	2,390	2390	2390	2390	2390	2390
Ammunition Group	2,962	2962	2962	2962	2962	2962
Transportation Terminal Group	6,923	6923	6923	6923	6923	6923
Trans Motor Transport Group	3,371	3371	3371	3371	3371	3371
Medical Group	3,615	3615	3615	3615	3615	3615
Aircraft Maintenance Battalion	586	586	586	586	586	586
Air Traffic Control Battalion	100	100	100	100	100	100
Graves registration Battalion	236	236	236	236	236	236
P&A Battalion	1,057	1057	1057	1057	1057	1057
PSYOP/Civil Affairs Battalion	400	400	400	400	400	400
EOD Detachment	57	57	57	57	57	57
Finance Organization	95	95	95	95	95	95
TAMCA(-)	25	25	25	25	25	25
TAMMC(-)	25	25	25	25	25	25
Daily Increase/Decrease:		**4000**	**8500**	**168**	**0**	**0**
Total Forces In-Country:		**128279**	**136779**	**136947**	**136947**	**136947**

APPENDIX 3, Theater Lines of Communications Construction and Rehabilitation Requirements

1. <u>Ports and Logistics Over The Shore (LOTS).</u>

a. Port facilty rehabilitation (Raysut):

Rehabilitate 30% damage to four berths	30,240 mh	6,600 ST
Repair damage to 30% of port roads	8,240 mh	360 ST
Clear debris	10,000 mh	
	48,480 mh	**6,960 ST**
b. Construct temporary lighterage wharf (2 ea)	**2,200 mh**	**54 ST**

c. Construct LOTS sites (Raysut):

Landing craft ramps (10 ea)	4,800 mh	
Stabilzed beach hardstand (100,000 sf)	5,550 mh	
	10,350 mh	
Subtotal effort	**61,030 mh**	**10,014 ST**
Desert construction factor	x 1.15	
Total Port Construction Effort	**70,184 mh**	**10,014 ST**

(Port Const Company day = 200 men x 16 hr/day = 3,200 mh)

Total port construction effort: 22 Port Const Co-days)

2. Airfields and Heliports.

a. Construction of a tactical airfield, forward COMMZ.

(1) Planning parameters:

Soil type	: Sand with well graded gravel
Soil Moisture	: Dry
Soil bearing capacity	: CBR > 4
Soil Thickness	: 2' to 20'
Slope	: < 2%
Vegetation	: Barren

(2) Using the following equation for estimation of effort for new tactical airfield construction in a support area (TM 5-330, page 11-11):

$$C_e = [25(V_s D_s + V_r D_r) + 2.0d + 2.4C]F$$

where C_e = Construction effort, in battalion days
V_s = Volume of soil removed
D_s = Relative difficulty of removing soil
V_r = Volume of rock removed
D_r = Relative difficulty of moving rock
d = Relative difficulty of providing drainage
C = Relative difficulty of clearing vegetation
F = Battalion-type factor

$$V_s = \frac{1(100-10)}{100} = .90 \quad ; \quad V_r = \frac{1(10)}{100}$$

$$C_e = [25(.90 \times .10 + .10 \times .15) + (2.0 \times .30) + (2.4 \times 0)].75$$

C_e = 15.75 Cbt Bn (Hvy) days x 1.15 (desert zone factor)

C_e = 18.1 Cbt Bn (Hvy) days

b. Rehabilitation of Thumrait airfield.

(1) Planning parameters. Using the same parameters as for new construction, effort will be based on 30% damage to facilties.

(2) Estimate will be calculated using the following equation for a heavy lift airfield in the support area (TM 5-330, page 11-11). Total calculated effort will be reduced to 30% based on damage estimate.

$$C_e = .3[37(V_s D_s + V_r D_r) + 3.7d + 4.4C]F$$

(3) Without going through the tedium of calculation explanation, and adjusted for construction in a desert zone, the estimation is:

C_e = 4.0 EN BN CBT (Hvy) Battalion-days

c. <u>Rehabilitation of Manston airfield.</u>

(1) Planning parameters. Using the same parameters as for new construction, effort will be based on 30% damage to facilties.

(2) Estimate will be calculated using the following equation for a medium lift airfield in the forward area (TM 5-330, page 11-10). Total calculated effort will be reduced to 30% based on damage estimate.

$C_e = .3[4.3(V_s D_s + V_r D_r) + .43d + .52C]F$

(3) Without going through the tedium of calculation explanation, and adjusted for construction in a desert zone, the estimation is:

C_e = .50 EN BN CBT (Hvy) Battalion-days

d. <u>Construction of heliport facilties in the theater.</u>

(1) Planning parameters. Same as for airports except that slopes will be between 2% and 10%.

(2) Using the following equations for estimation of effort for new heliports (TM 5-330, page 11-15):

Light aircraft - Support zone: $C_e = [1.7(V_s D_s + V_r D_r) + .17d + .19C]F$
(UH-60/AH-64) Forward zone: $C_e = [1.2V_s D_s + V_r D_r) + .12d + .15C]F$

Medium aircraft - Support zone: $C_e = [10.0(V_s D_s + V_r D_r) + 1.0d + 1.2C]F$
(CH-47) Forward zone: $C_e = [4.2(V_s D_s + V_r D_r) + .42d + .51]F$

$(V_s D_s + V_r D_r) = 1.8 \times .1 + .40 \times 1.5 = .78$

(3) Therefore, for construction effort per company size aviation unit:

	Support	Forward
Light :	1.1	.95
Medium :	5.9	3.3

Adjusting for the desert zone (x 1.15):

	Support	Forward
Light :	1.3	1.1
Medium :	6.8	3.8

(4) Construction effort estimate for heliports in support of type units:

Type Unit	# Light Companies Fwd (1.1)	# Light Companies Spt (1.3)	# Medium Companies Fwd (3.8)	# Medium Companies Spt (6.8)	CBT EN (HVY)	Corps[1] EN BN	Division[1] EN BN
					(All in battalion days)		
Corps AVN BDE	-	24	-	3	**51.6**	103.2	NA
Air ASLT DIV	15	-	3	-	**27.9**	48.4	96.8
Airborne DIV	8	-	-	-	**8.8**	17.6	14.7[2]
Light INF DIV	6	-	-	-	**6.6**	13.2	96.8
Mech INF DIV	8	-	-	-	**8.8**	17.6	22.0[3]
Command Avn CO	-	1	-	-	**1.3**	2.6	NA

Total EN BN CBT (Hvy) Battalion-days : 105.0

3. Pipeline requirements (Reference FM 101-10-1/2, p. 1-51).

a. POL.

(1) Raysut to Salalah (Avn fuel).

6" pipe, 17 miles (785 bph)	10,594 mh	590 ST

(2) Forward tactical airfield supply (Avn Fuel).

6" pipe, 17 miles (785 bph)	10,594 mh	590 ST
POL shore booster station	6,066 mh	175 ST

b. Waterlines.

COMMZ hospital complex in support area (Muscat).

4" pipe, assumed 16 miles.	9,568 mh	374 ST
Pumping station	5,355 mh	132 ST
Subtotal, pipeline requirements:	42,174 mh	1,861 ST
Desert zone (mh x 1.15)	48,500 mh	1,861 ST

(One Pipeline Construction Company-day = 170 men x 16 hrs/day = 2,270 mh)

Total pipeline effort: 21.4 Pipeline Construction Company-days

[1] Conversion factors based on battalion-type factors found on page 11-9, TM 5-330.
[2] Augmented with airborne light equipment company.
[3] Estimate by author.

4. Road rehabilitation (Reference FM 101-10-1/2, pp 1-45, 1-46).

a. Major effort will involve rehabilitation of the designated primary highway linking the COMMZ support base with the forward support area in the CZ. Effort will not be required until approximately D+15.

b. One gross estimate will be used as an estimate for all major roadwork in the theater. No bridge rehabilitation expected.

Assumed 900 km, 24'double lane x 2,619 mh/km, (for new construction)		2,354,400 mh	69,927 ST
x Rehabilitation factor (.15)	=	353,160 mh	10,489 ST
x Desert zone factor (1.15)	=	406,134 mh	10,489 ST

(one EN BN CBT (Hvy) day = 550 men x 16 hrs/day = 8,800 mh)

Total road rehabilitation effort: 46.2 EN BN CBT (Hvy) days 10,489 ST

APPENDIX 4, Theater Facility Construction Requirements.

1. <u>COMMZ facilities.</u>

a. Maintenance facilties (assumed minimum).

AVIM Company (2 ea)	168,000 sf	90,810 mh
Collection & Class Company	6,300 sf	3,405 mh
Hvy Equip Maint Co (GS)	4,513 sf	2,440 mh
Conventional ammo company	53,820 sf	29,092 mh
	232,633 sf	125,747 mh

(From adjusted estimate, TM 5-333, p. 9-2: 960 sf/520 mh = 1.85 sf/mh)

b. Supply facilties. Supply facilities will be provided with normal TO&E equipment found in all units (e.g. POL will be stored in fuel bladders).

c. Administrative facilties (assumed minimum).

Two complexes, approx. 300 men each.	59,892 mh

d. Medical and Dental facilities.

General hospital, 5 ea (5,000 beds)	1,355,420 mh
Field hospital, 2 ea (1,000 beds)	370,904 mh
Station hospital, 2 ea (1,000 beds)	370,904 mh
	2,097,228 mh

e. Troop camp facilities (66% of COMMZ population).

3,000 man camp, steel frame, 9 ea	1,219,878 mh
250 man camp, 2 ea (along LOC)	49,610 mh
	1,269,488 mh

f. POW camp facilties (4,000 POW). 233,972 mh

g. Summary of construction effort:

Facilities type	man-hours	EN BN CBT (Hvy)-days
Maintenance	125,747	16.4
Administrative	59,892	7.8
Medical and dental	2,097,228	274.1
Troop camps	1,269,488	165.9
POW camps	233,972	30.6
		494.8

(one EN BN (CBT Hvy) day = mhs x 1.15/(550 men x 16 hrs/day) = 8,800 mh)

2. Storage Requirements.

a. Covered storage requirements.

	Class	Planning Population	x	Storage[2] Factor	x	Storage[3] Objective	Required (Ft²)
Combat Zone	I[1]	110,000		.0353		3	11,649
	II	109,000		.0169		3	5,526
	III(p)	109,000		.0005		3	164
	IV	109,000		.0073		3	2,387
	V	109,000		.0063		3	2,060
	VI	109,000		.0248		3	8,100
	VII	109,000		.0055		3	1,799
	VIII[1]	110,000		.0054		3	1,782
	IX	109,000		.0077		3	2,518
							35,995
COMMZ	I[1]	155,000		.0353		7	38,300
	II	150,000		.0169		7	17,745
	III(p)	150,000		.0005		7	525
	IV	150,000		.0073		7	7,665
	V	150,000		.0063		7	6,615
	VI	150,000		.0248		7	26,040
	VII	150,000		.0055		7	5,575
	VIII[1]	155,000		.0054		7	5,859
	IX	150,000		.0077		7	8,085
							116,219

Summary:

Location :	Combat Zone (Salalah)	COMMZ (Muscat)
Required :	35,995	116,219
Available (@ 25%): Space	26,910	53,820
Additional : Space	9,085	62,399

REQUIRED CONSTRUCTION: Covered Storage Area: 71,484 sf = 38,640 mh

(From adjusted estimate, TM 5-333, p. 9-2: 960 sf/520 mh = 1.85 sf/mh)

Covered storage construction required: 4.4 EN BN CBT (Hvy) days

(one EN BN (CBT Hvy) day = mhs x 1.15/(550 men x 16 hrs/day) = 8,800 mh)

[1] EPW estimates added to US/Omani forces for Classes I and VIII requirements.
[2] FM 101-10-1/2, page 1-41.
[3] Based on AMSP student guidance: 10 DOS in theater - 3 DOS in CZ, 7 DOS in COMMZ.

b. Open Storage Requirements.

	Class	Planning Population	x	Storage[1] Factor	x	Storage[2] Objective	Required (Ft²)
Combat Zone	V	109,000		.0063		3	2,060
	Pers	21,000[3]		16.20 sf		-	340,200
	Vehicles	4,200[4]		15 sf		-	63,000
							405,260
COMMZ	V	150,000		.0063		7	6,615
	Pers	42,000		16.20 sf		-	680,400
	Vehicles	8,400[4]		15 sf		-	126,000
							813,015

Summary:

Location	Combat Zone (Salalah)	COMMZ (Muscat)
Required :	405,260	813,015
Available (@ 25%): Space	882,200	430,560
Additional : Space	0	382,455

REQUIRED CONSTRUCTION: Open Storage Area: 382,455 sf = 8.8 acres

(open storage site preparation rate 168 mh/acre; .02 Bn day/acre)

Open storage construction required: .20 EN BN CBT (Hvy) days

Notes:
[1] FM 101-10-1/2, page 1-41.
[2] Based on AMSP student guidance: 10 DOS in theater - 3 DOS in CZ, 7 DOS in COMMZ.
[3] Estimate of personnel in corps rear area.
[4] Vehicle estimates based on 1 vehicle per 5 personnel.

c. Cold Storage Requirements.

	Class	Planning Population	x	Storage[2] Factor	x	Storage[3] Objective	Required (Ft³)
Combat Zone	I[1]	110,000		.0835		3	27,755
	VI	109,000		.0221		3	7,227
	VIII[1]	110,000		.0048		3	1,584
	IX	109,000		.0017		3	556
							37,122
COMMZ	I[1]	155,000		.0835		7	90,598
	VI	150,000		.0221		7	23,205
	VIII[1]	155,000		.0048		7	5,208
	IX	150,000		.0017		7	1,785
							120,796

Summary:

Location	:	Combat Zone (Salalah)	COMMZ (Muscat)
Required	:	37,122	120,796
Available (@ 50%) Volume	:	0	0
Additional Volume	:	37,122	120,796

Required Cold Storage Area : 157,978 cf

Cold storage will be provided by TO&E equipment found in QM and TC organizations.B

Notes:

[1] EPW estimates added to US/Omani forces for Classes I and VIII requirements.
[2] FM 101-10-1/2, page 1-41.
[3] Based on AMSP student guidance: 10 DOS in theater - 3 DOS in CZ, 7 DOS in COMMZ.

TAB 1 (Hospital Requirements) to APPENDIX 4, Theater Facilities Construction Requirements

1. Combat Zone:

PD	EP	Div Trps	Non-Div Trps	Total	CZ Accumulation Factors 1	2	3	4	CZ Patients 1	2	3	4
WIA:												
1	7	57.5	18.0	75.5	3.11				235			
2	7	126.5	17.2	143.7		3.11				446		
3	7	126.5	17.2	143.7			3.11				446	
4	7	126.5	17.2	143.7				3.11				446
DNBI:												
1	7	49.5	72.0	121.5	2.78				337			
2	7	108.9	68.8	177.7		2.78				493		
3	7	108.9	68.8	177.7			2.78				493	
4	7	108.9	68.8	177.7				2.78				493
Total patients in Combat Zone:									572	940	940	940
x Combat Zone Dispersion Factor (1.33)												
= Combat Zone Bed Requirements at end of period									**760**	**1250**	**1250**	**1250**

2. Communications Zone

PD	EP	CZ Trps	COMMZ Trps	Total	COMMZ Accumulation Factors 1	2	3	4	COMMZ Patients 1	2	3	4
WIA:												
1	30	75.5	2.8	78.3	15.1				1179			
2	30	143.7	2.1	145.8		15.1	2.6			2196	382	
3	30	143.7	2.1	145.8			15.1	2.6			2196	382
4	30	143.7	2.1	145.8				15.1				2196
DBNI:												
1	30	121.5	52.3	173.8	10.8				1885			
2	30	177.7	39.9	217.6		10.8	.95			2361	208	
3	30	177.7	39.9	217.6			10.8	.95			2361	208
4	30	177.7	39.9	217.6				10.8				2361
Total patients in COMMZ:									3064	4557	5146	5146
x COMMZ Dispersion Factor (1.25)												
= COMMZ Bed Requirements at end of each period									**3830**	**5700**	**6430**	**6430**

NOTE: a. Columns may not total due to rounding.
b. PD=period; EP=evacuation policy
c. Reference is FM 101-10-1/2, Chapter 5, Section V.

BIBLIOGRAPHY

BOOKS.

Beck, Alfred M., Abe Bortz, Charles W. Lynch, Linda Mayo, and Ralph W. Weld. *The Corps of Engineers: The War Against Germany*. Washington: US Government Printing Office, 1985.

Bradley, Omar N. and Clay Blair. *A General's Life*. New York: Simon and Schuster, 1983.

Coll, Blanch D., Jean E. Kerth, and Herbert N. Rosenthal. *The Corps of Engineers: Troops and Equipment"*. Washington: US Government Printing Office, 1958.

Harrison, Gordon A. *Cross-Channel Attack*. Washington: US Government Printing Office, 1951.

Hicks, Patrick (editor). *Jane's Containerisation Directory 1989-90*. Surrey, United Kingdom: Jane's Information Group, Limited, 1989.

Jomini, Baron de. *The Art of War*. New York: G.P. Putnam and Company, 1854. Reprinted by USACGSC, FT Leavenworth, 1989.

Polmar, Norman. *Ships and Aircraft of the U.S. Fleet (14th Edition)*. Annapolis, Maryland: Naval Institute Press, 1989.

Ruppenthal, Roland G. *Logistical Support of the Armies, Volumes I and II*. Washington: US Government Printing Office, 1953.

Van Creveld, Martin. *Supplying War: Logistics from Wallenstein to Patton*. Cambridge, England: Cambridge University Press, 1977.

Weigley, Russell F. *Eisenhower's Lieutenants*. Bloomington, Indiana: Indiana University Press, 1981.

U.S. GOVERNMENT DOCUMENTS, MANUALS, PAPERS, AND REPORTS.

Carter, William A. Jr. *Employment and Staff Procedures of Engineers with Divisions, Corps, and Armies*. HQ, First US Army. March, 1946.

Defense Mapping Agency. Map Series ONC, Sheet J-7 (1:1,000,000), edition 8-GSGS. Washington: US Government Printing Office, 1982.

__________. *World Port Index (Tenth Edition)* (Publication 150). Washington: US Government Printing Office, 1987.

Department of the Army. Field Manual 5-30, *Engineer Intelligence*. Washington: US Government Printing Office, September 67.

__________. Field Manual 5-100, *Engineer Combat Operations*. Washington: US Government Printing Office, November 88.

__________. Field Manual 5-104, *General Engineering*. Washington: US Government Printing Office, November 86.

__________. Field Manual 5-116, *Engineer Operations: Echelons Above Corps*. Washington: US Government Printing Office, March 89.

__________. Field Manual 31-82, *Base Development*. Washington: US Government Printing Office, June 71.

__________. Field Manual 100-5, *Operations*. Washington: US Government Printing Office, May 86.

__________. Field Manual 100-15, *Corps Operations*. Washington: US Government Printing Office, September 89.

__________. Field Manual 100-16, *Support Operations: Echelons Above Corps*. Washington: US Government Printing Office, April 85.

__________. Field Manual 101-10-1/2, *Staff Officers' Field Manual Organizational, Technical, and Logistical Data Planning Factors (Vol 2)*. Washington: US Government Printing Office, October 87.

__________. Field Manual 101-10-2, *Extracts of Non-Divisional TOE*. Washington: US Government Printing Office, July 77.

European Theater of Operations, US Army (Forward Echelon). "Communications Zone Plan," 14 May 1944.

Joint Chiefs of Staff. JCS Pub 3, *Joint Logistics Policy and Guidance (U), Vol I*. Washington: July, 1979.

Headquarters, XVIIIth Airborne Corps. *XVIII Airborne Corps/ ARFOR OPLAN 2-80 - POSITIVE LEAP 80,* (declassified on 9 Oct 86). FT Bragg, NC: 10 Mar 1980.

Moore, C.R. *Final Report of the Chief Engineer - European Theater of Operations, 1942-45, Volumes I and II*. 1949.

Nyrop, Richard F. (editor). *Persian Gulf States Country Studies* (also referred to as *DA Pam 550-185*). Washington: US Government Printing Office, 1984.

Peterson, Stephen P. *Operational Sustainment: The Impact of Critical Decisions Upon Operational Design*. FT Leavenworth: School of Advanced Military Studies, USACGSC, May 89.

Schneider, James J. *Theoretical Paper No. 3*. FT Leavenworth, KS: US Army Command and General Staff College, 1 March 88.

US Army Engineer School. "TAA 96 Allocation Rules." FT Leonard Wood, MO: 26 Dec 1989.

__________. "TAA 96 Force Program Review." FT Leonard Wood, MO: 1989.

US Army School of Advanced Military Studies. *USCENTCOM Exercise 1990, SWA (AMS Lesson 3-11)*. FT Leavenworth: 1990.